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PLATE III.

EDWARD CHARLES PICKERING

Born July 19, 1846; died February 3, 1919

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EDWARD CHARLES PICKERING

BY EDWARD S. KING

PROFESSOR EDWARD CHARLES PICKERING, Director of the Astronomical Observatory of Harvard College, died on February 3, in the seventy-third year of his age.

Born in Boston on July 19, 1846, of vigorous New England stock, he possessed a rich heritage in his ancestry. They were all able, well-educated, cultured men, active in life, engaged in the professions, in large business enterprises, or in the public service. His great-grandfather, Timothy Pickering, born in Salem, Mass., studied law after graduation from Harvard in 1763, and was admitted to the bar. He was interested in public defense, publishing an "Easy Plan of Discipline for a Militia," which was adopted by the General Court of Massachusetts. In the Revolution he served under Washington in high military capacities. Later, he became successively Postmaster-General, Secretary of War, and Secretary of State.

Having such a lineage, it was natural that Edward Charles Pickering should have developed early. As a boy he had keen

interest in science, finding great delight in a view of Jupiter and its satellites which he obtained with a small telescope. Even then, his thoughts were not so much on the spectacle, as on the problems presented by such a system. At the Boston Latin School he had as a schoolmate, John Trowbridge, under whom at a later date, the Jefferson Physical Laboratory at Harvard was built up. Both lads came from the Boston school to Harvard, entering the Lawrence Scientific School, from which Pickering was graduated at the age of nineteen. He was at once made an instructor in mathematics at Harvard. Two years later he was appointed Thayer Professor of Physics at the Massachusetts Institute of Technology, which position he held for nine years.

His enthusiasm now found a wide field. His original way of doing things expressed itself in establishing the first physical laboratory in the United States, on lines which have been copied extensively elsewhere. For use in this work he published his "Elements of Physical Manipulation." Not content to have the students make the experiments themselves, he encouraged them to original investigation. This plan resulted in many papers, signed either by the student, or in some cases, jointly by the student and himself. These papers were published mostly in the Proceedings of the American Academy of Arts and Sciences, of which body he had already been made a Fellow. His election took place November 13, 1867, when he was 21 years old, and he is believed to be the youngest candidate who ever received that honor. On the same date the Academy elected as an Associate Fellow, Dr. C. H. F. Peters, of the Litchfield Observatory at Clinton, N.Y. Thus, the representatives of the "old astronomy" of position, and of the "new astronomy" of astrophysics, were brought together.

It was in these days that he made experiments in sound, anticipating the telephone. These experiments were described and exhibited publicly and privately. No patent was taken out, from his belief that "a scientific man should place no restriction upon his work which would prevent the repetition of an experiment of scientific interest." Professor Pickering had the faculty

of presenting the most abstruse subjects in an entertaining way. For example, his article on Applications of Fresnel's Formula, in spite of the mathematics, contains sidelights explaining everyday phenomena, which appeal to the reader's own observation.

His growing interest in astronomy was shown by his accompanying the Nautical Almanac Party to observe the total solar eclipse of 1869, when he used both spectroscope and polariscope to good purpose. The following year he was a member of the U.S. Coast Survey Eclipse Party, which went to Xeres, Spain.

While at the Institute he married, in 1874, Lizzie Wadsworth Sparks, daughter of Jared Sparks, at one time president of Harvard College. In October, 1876, Professor Pickering, at the age of 30, was appointed as the fourth director of the Harvard Observatory, succeeding Professor Joseph Winlock, who had died the previous year. On February 1, 1877, he moved to Cambridge and assumed the duties which were to be his for 42 years. The appointment of a physicist to such a position aroused some criticism, but the wisdom of the choice was soon made manifest. He found at the Observatory four assistants, "two instruments of largest size and finest quality," and a mass of observations not yet reduced in form for publication.

Looking forward with the far vision which was his, he lays down two principles:—"First, to avoid a duplication of the work done elsewhere with other large telescopes; and secondly, that the observations shall be of such a kind that they cannot be made equally well with a smaller instrument." Reviewing the work at other observatories, he decides that photometry "offers a field almost wholly unexplored with large telescopes," and gives that department his choice. The discovery of the satellites of Mars afforded an immediate opportunity for measuring the brightness of these faint objects, which he accomplished with great ingenuity in several ways. He introduced also a new method of observing the eclipses of Jupiter's satellites by accepting as the time of eclipse, the instant when the satellite had lost or regained just half of its normal light. This photometric method did not prevent

the observations of disappearance and reappearance being also made in the old way.

Meanwhile, with appreciation of "scientific management," he asserted that costly instruments should be kept constantly engaged, and indicated that with the endowment sufficient to meet the current overhead expenses of the Observatory, an increase of 40 per cent. in the income would more than double the scientific output, and bring the institution to a state of greater efficiency. In response, a subscription was raised which afforded $5,000 annually for five years. President Eliot, in his report for that year, says:—"The Director is to be congratulated that his own enthusiasm has won such sympathy and support." It is indicative of Professor Pickering's earnestness that he was one of the largest subscribers on the list, and also prophetic of the time later when, year after year, he turned in his own salary for the good of the Observatory. It is not the present purpose to give an account of the financial growth of the Observatory's endowment to the million-dollars it attained before his death. It is sufficient to say that under his wise administration each successive gift not only yielded the desired scientific results, but, by increasing efficiency, enhanced the productiveness of those which followed.

The scientific work of the Observatory under Professor Pickering can be treated here only in outline. His policy of entering the field of photometry did not cause him to neglect the older line of research usually called the "old astronomy." Besides other determinations, two zones of stars were measured, as a part of the great international undertaking which had for its object the accurate observations for position of all stars down to the ninth magnitude. Each of these zones occupied the time of an observer and two corps of assistants for nearly a quarter of a century.

His experiments as a physicist, inclined to studies in optics and especially in polarization, resulted in the early invention and use of the "Meridian Photometer." With this and similar instruments large numbers of stars were measured and reduced to a system of magnitudes now generally adopted as standard. Desiring to extend the photometric and other observations to the south-

ern hemisphere, he sent Professor Bailey in 1889 to South America, where he used the photometric and also photographic, as well as meteorological, instruments at three different stations in Peru and on the west slope of the Andes. As the result of Professor Bailey's work, and on his recommendation, the southern station of the Observatory, under the Boyden Fund, was located at Arequipa, Peru. All stars of the 7.0 magnitude or brighter were observed to the South Pole of the sky. Later, Professor Pickering, using a 12-inch telescope at Cambridge, measured large numbers of the fainter stars. The grand total of these investigations gives observations of 80,000 stars, and the number of estimates, including those made with the 15-inch equatorial, exceeds two million. The indefatigable energy, as well as the patient industry, of Professor Pickering is shown by the fact that one and one-half million of these photometric settings were made by him personally.

With relation to his work in photography, the Report of the Visiting Committee for 1916 says:—

> The first image of a star ever made on a photographic plate was taken by Professor G. P. Bond in 1850. The development of photographic astronomy since that date has been little short of marvellous.
>
> In this work Harvard has taken a most important part. During the last quarter of a century the history of the entire sky has been permanently preserved by photography. Through all these years a "sky patrol" has been kept without interruption, the station at Arequipa, Peru, supplementing the work at Cambridge.
>
> We thus have a complete history of the stars down to the eleventh magnitude during the past twenty-five years, written by the stars themselves on a quarter of a million plates. This history is duplicated nowhere on earth. The weight of the glass of these photographs is one hundred and twenty tons.
>
> It hardly needs to be stated that this rich mass of material has never been adequately studied, but on that account it is not less valuable, for like all other historical records it grows more important with the passing years.

This continual and repeated charting of the sky has amply justified Professor Pickering's foresight. The early history of Nova Aurigae before its discovery, was recorded on the plates of

the Transit Photometer. Professor Pickering was able to plot the path of the asteroid Eros in the sky during its near approach to the earth in 1894, from photographs taken four years before it was known to exist. The nova of last summer was traced back for 30 years. Indeed, from this photographic library several hundred plates may be found of any region, whether in the northern or the southern hemisphere of the sky, which the astronomer may wish to examine.

The collection of photographs includes not only charts of the stars, but also their spectra obtained with the objective prism. The well-known Draper Classification, derived from these plates, has been adopted by the International Union of Solar Research, and hundreds of requests from astronomers all over the globe are made for the classification for special lists of stars. The "New Draper Catalogue," for which Miss Cannon has classified over 200,000 stars, is complete in manuscript; and two of the nine volumes are already published. It is hoped that the others may soon follow.

The determination of photographic magnitudes is a very difficult problem and only recently has success been achieved. Recognition of Professor Pickering's work in this respect has been noted in the Visiting Committee's Report of 1915:—

> For a quarter of a century, eighteen observatories of the world have been working on a photographic map and catalogue of the sky commonly called the Astrographic Catalogue. This investigation has been hampered for want of a photographic scale of magnitudes, and a committee was appointed to consider the proper scale to adopt for this great international undertaking. On this committee were astronomers from England, France, Germany, Russia, Holland, and the United States.
>
> Professor Pickering had the honor of being elected Chairman of this committee. The decision in the matter was most complimentary to Harvard, for the committee adopted the Harvard magnitudes of the polar sequences as its standard, and, as a starting point, the magnitudes given in the *Revised Harvard Photometry, Annals*, Volume 50, of stars whose spectra are of class A, and whose magnitudes are 5.5 to 6.5. As this has been adopted universally by astronomers, the Observatory has now extended this standard on a large scale to other portions of the sky.

Professor Pickering's notable work on variable stars was recognized when the Gold Medal of the Royal Astronomical Society was presented to him in 1901. He occupies a unique position in that this was the second medal presented to him by the Royal Astronomical Society, the first having been given him in 1886, conjointly with Professor Pritchard of Oxford, in honor of his achievements in stellar photometry.

Thus Professor Pickering's work in photometric magnitudes, photographic magnitudes, classification of spectra, and also of variables, has become universally the standard.

A complete list of the medals and other distinctions received by him from universities and societies at home and abroad is too long to be entered here. Almost every scientific honor came to him. As President of the American Astronomical Society, he was known and beloved of all its members.

He was an indefatigable worker, as well as a great organizer. His interest extended to every department of the Observatory work, whether research, routine observation, reduction of observations, or publication. He thought in broad lines, but no detail was too small for his attention. He was always devising new methods or apparatus. He enjoyed following the large pieces of routine work. He was wont to use graphical methods to show the progress, and what gaps needed to be filled. In this connection, he took great delight in showing graphically not only how many variables had been found in a particular area of the sky, but how many had probably escaped the keen eye of the observer. The reduction of all observations was carefully planned, for as he said in regard to the New Draper Catalogue, a difference of one minute per star would mean two years of an assistant's time. As to the publications, he had regard to all the niceties of literary and typographical excellence, and never seemed to consider the labor of carefully reading copy and proof as arduous. This was a large task. Volume 92 of the Annals, in bound form, was placed in his hands a few days before his last illness. Copy on hand waiting for publication would have carried the Annals beyond the hundredth volume. More than eighty volumes had been prepared and dis-

tributed during his directorate. They were his pride, the children of his creative genius.

Professor Pickering left no family. His nearest surviving relative is his brother, Professor William Henry Pickering, now in charge of the Harvard Astronomical Station at Mandeville, Jamaica.

Professor Pickering's interest was not confined to astronomy. He was fond of music and in his youth played the flute. He always found great refreshment in listening to good music, and as Mrs. Pickering was an accomplished pianist, it was an established custom for her to play to him every evening when he was not engaged in work. After her death in 1906, he still found solace in music through the aid of a gramophone, for which he had an extensive and well-chosen collection of records. He enjoyed chess, playing a fair, though not a deep, game. For years, in earlier life, he took long bicycle rides, exploring all the outlying territory about Cambridge. He always liked to share his enthusiasms, and thus his love of the mountains found expression in the forming of the Appalachian Mountain Club, of which he was the first president. The Club now consists of more than 2,000 members. Yet he mingled science with pleasure, for he devised the "Micrometer Level" by which he could plot mountain topography.

Professor Pickering, like his ancestor, Timothy Pickering, was zealous for the public defence and was prolific in suggestions and important services in respect to the scientific aspects of the present war. He showed how a submarine near the surface of the water might be seen in spite of the glare of the sun by using a Nicol prism. One of his latest interests was the "Pickering Polaris Attachment," as it is now called in the U. S. big gun corps. This device, attached to a surveyor's transit, makes it possible, with no computation or tables, and, without knowing the latitude or time, to obtain the orientation for directing the heavy artillery toward the distant unseen target.

During his directorate, a system of correspondence with observatories and private astronomers at home and abroad was

built up, until the Harvard Observatory became the distributing centre, a clearing house of astronomical news.

He was a great believer in co-operation and was glad to unite in the work of other observatories. Co-operative work was being carried on by him with Professor Kapteyn of Groningen, Holland; with the Mount Wilson Observatory; with Professor Plaskett of the Victoria Observatory; and with other individuals and institutions. He was always ready to lend a helping hand. In the letters received since his death, many of the writers speak of the debt they owe Professor Pickering for his interest and help in their work, and the encouragement they had received from his spirit of helpfulness.

The world honored him as a great astronomer and organizer, but we who have worked with him at the Observatory, like all who came to know him, mourn the loss of a sympathetic, inspiring and great-hearted friend.

HARVARD COLLEGE OBSERVATORY,
CAMBRIDGE, MASS.

THE SPECTROSCOPIC BINARY H. R. 8170

By J. S. Plaskett

THIS star in Cygnus of R. A. 21 h. 17.2 m., Dec. + 39° 55′ (1900), of Spectral Type F8 and photographic magnitude 6.96, is the first spectroscopic binary to be discovered and have the elements of its orbit determined at Victoria. It is of interest on account of its short period and large range, rather unusual in stars of this type, and it was these characteristics, evident on the measurements of the first two or three plates, that led to the securing of observations for the determination of the orbit.

There is, however, a further interest attached to this orbit on account of the evidence it presents as to the quality of the work obtainable by the telescope and spectrograph at the new observatory. In consequence, the details have been arranged and the solutions carried through with this end in view.

The star, which is No. 27 of the list of binaries discovered here and announced in this Journal, was placed on the radial velocity programme last August, the first plate being secured on August 23. Measurement of the first four plates early in November showed it to be of large range and short period, and further observations were obtained as often as possible between Nov. 23 and Dec. 23. In all, 15 plates have been used in determining the elements, and although four months may seem a short time to obtain a final period, there have been nearly 40 cycles in that interval, while the large range and the accuracy of the observations make it relatively closely determined, the probable error of the period being less than three ten-thousandths of a day.

All of the spectra have been secured by the new spectrograph of the observatory, arranged for use with one prism and a camera of medium focus. The linear dispersion given by this combination at $H\gamma$ is about 35 A per millimetre. The plates have all been

measured on the Hartmann Spectro-Comparator, which experience here has shown will give in stars of the F or later types, measures equally or more accurate than on the micrometer microscope, and in considerably less time.

In Table I, the data of the observations and measures of the 15 plates used are given. In the first column is contained the serial number of the plate, in the second the Julian date of the observation. The third column gives the exposure time in minutes, the fourth the phase from periastron and the fifth the measured velocity reduced to the sun. The sixth and seventh columns contain the residuals of the individual plates, in the sense observed minus computed, from the preliminary and final orbits.

TABLE I.

Plate No.	Julian Date	Exposure Time	Phase	Velocity	Residuals O-C	
					Preliminary	Final
478	2,421,829.326	20 m	2.330	— 15.64	— 1.98	— 0.96
661	875.713	19	2.809	+ 40.95	+ 0.77	+ 0.35
691	886.677	17	1.286	— 46.01	— 0.60	+ 0.07
706	886.677	21	0.799	+ 3.08	+ 0.21	— 0.93
933	921.562	28	0.006	+ 64.90	— 0.49	— 0.13
939	922.568	19	1.012	— 21.73	— 1.24	— 2.01
963	924.553	18	2.997	+ 55.21	— 0.28	+ 2.05
990	928.561	18	0.518	+ 37.23	+ 0.65	+ 0.77
1033	939.569	19	1.796	— 55.50	+ 0.09	+ 1.47
1044	943.587	25	2.571	+ 16.00	+ 4.55	+ 1.91
1078	948.544	16	1.041	— 22.47	+ 0.35	+ 1.37
1084	948.628	20	1.125	— 33.12	— 2.00	— 1.10
1106	949.560	23	2.057	— 42.10	+ 0.17	— 0.15
1110	949.662	25	2.159	— 34.92	— 1.03	— 2.06
1128	951.552	20	0.805	+ 4.15	+ 0.21	+ 0.77

Some little difficulty in obtaining the preliminary period was encountered, but when this was determined the remainder of the work followed the usual course. Preliminary elements which were obtained graphically are given in Table II, the resulting residuals appearing in Table I. Examination of these residuals showed that these elements were probably not as good as could be obtained, and a least squares solution, using the differential co-efficients obtained by Lehmann-Filhes, was applied. Owing to the small value of the eccentricity, it was not considered advisable to use

co-efficients for both T and ω, consequently the former was considered fixed at J.D. 2,421,801.549, while corrections were calculated for the period, eccentricity, amplitude, longitude of the apse and velocity of the system. The application of a correction for the period rendered it advisable to use the plates singly and not combine them into normal places, and although this might have been done for the two cases when two plates were obtained on the same night, it was considered more direct and satisfactory to treat all the observations separately.

The results of the solution giving the values of the elements, with their probable errors, are given in Table II, while comparison of the final with the preliminary residuals in Table I shows the improvement effected. The sum of the squares has been reduced from 33.16 to 24.52, while the general run of the observations and their agreement with the final elements is graphically exhibited in the velocity curve accurately drawn to scale.

TABLE II.

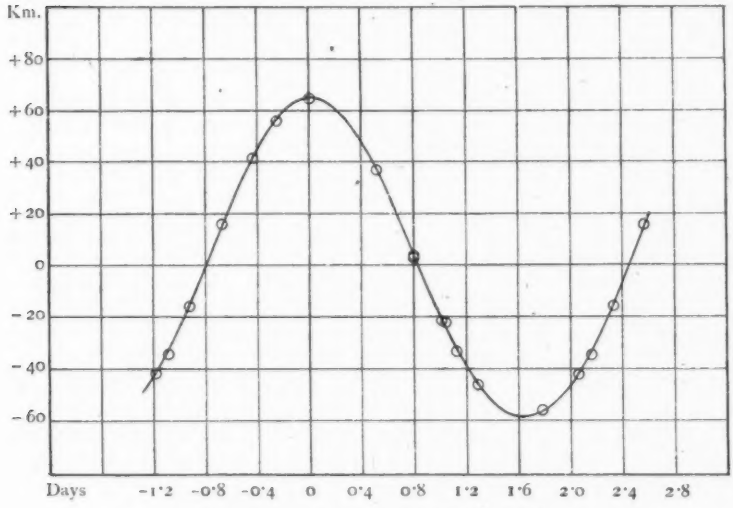
Element	Preliminary	Final
U = Period	3·2442	3·24343 ± ·00027 days
e = Eccentricity	0·04	0·0223 ± ·0086
K = Half Amplitude	61·5	62·23 ± 0·46 km.
γ = Velocity of System	+ 1·5	+ 1·44 ± 0·29 km.
ω = Longitude of Apse	0	357°·55 ± 1·01
T = Time of Periastron Passage	1·549	J. D. 2,421,801·549
$a \sin i$ = Projected semi-axis Major	2,741,000	2,773,000 km.

It may be of interest to point out that, although the spectra are all sufficiently exposed and that on some nights the seeing was poor and clouds interfered, the average time given for this star of 6.96 photographic magnitude was only about 20 minutes. With good silver surfaces and fair seeing, good spectra could be obtained in 15 minutes. This is for a linear dispersion at Hγ, as previously stated, of 35 A per millimetre, and is an indication not only that the makers have produced optical surfaces of the highest grade, but that temperature difficulties have been so far

overcome that excellent figure under observing conditions is maintained, and further, that the "seeing" conditions at Victoria are generally good.

The discussion of the 15 spectra from which this orbit has been obtained gives a good idea of the accuracy of the radial velocity determinations obtainable with the spectrograph. A glance at the column of final residuals show them to be all satisfactorily small considering the low dispersion, the greatest being only slightly over 2 km. per second, the mean 1.07 km. and the probable error of a single plate ± 0.89 km. When it is considered that with 3 prism spectrographs giving linear dispersion of about 10 A—three and a half times greater than that used here—the probable error of a plate is of the order of 0.5 km., we have good reason to be satisfied with the accuracy and to have confidence in the velocity values obtained.

It may interest the readers of this JOURNAL to know that the prism now being used as the dispersing medium in the spectro-



VELOCITY CURVE OF H.R. 8170

graph at Victoria, and with which the spectra used in the orbit of the above binary were obtained, really belongs to the Department of Astronomy at the University of Toronto. Owing to the impossibility of obtaining suitable material for such prisms during the war, this prism, which is of the finest quality, as is evident from the accuracy of the velocity values obtained, was kindly temporarily loaned to the Observatory by Prof. C. A. Chant, better known to most of you as the Editor of this JOURNAL.

DOMINION ASTROPHYSICAL OBSERVATORY,
VICTORIA, B.C.
Feb. 3, 1919.

Nu GEMINORUM, A LONG PERIOD BINARY

By W. E. Harper

1900 $\alpha = 6^h\ 23^m{\cdot}0$, $\delta = +\ 20°\ 17'$, Mag. 4·06, Type B5

THIS star was announced as a spectroscopic binary by Lee, in the Astrophysical Journal, Vol. 32, p. 301, from 5 plates taken in the years 1901 to 1909 which showed a range of 27 km. It was noted that the H and K lines of calcium gave velocities different to the other lines.

A series of plates were made here during the years 1910-11-12-13-14 and 52 of these plates were measured by Mr. T. H. Parker without them giving any clue to the period. When Mr. Parker responded to a higher call and went overseas the star was taken over by the writer and plates have been made from time to time so that now we have 83 altogether. While Mr. Parker's measures were felt to be just as reliable as any that could be made upon the plates, yet owing to the complex character of the lines and the possibility of different interpretations being placed upon them it was thought better for the writer to measure all the plates and thereby possibly secure greater homogeneity.

While the helium lines λ4471 and λ4026 can be detected on most of our plates they are, with possibly the exception of one plate, entirely too faint to be measured and consequently the results depend upon the four hydrogen lines, $H\beta$, $H\gamma$, $H\delta$, and $H\epsilon$. $H\epsilon$ is only rarely used, $H\gamma$ is by far the most dependable line with $H\delta$ next in order and then $H\beta$. The numbers 9, 4 and 3 would express the relative weights of these three. The measures of the calcium line K have been kept separate as Lee's discovery of its distinct character has been verified even though the line lacks contrast and is of extremely poor quality for measurement. While the extreme variation shown for measures

of this line is in the neighborhood of 50 km. yet this range is only shown where the line is very poor and the measurement uncertain and it is not likely that the real range is much over half this amount. There does not seem to be any progressive variation over a long period as is the case for the hydrogen lines; the velocities for each year average up about the same. The weighted mean velocity for the line on 33 plates is + 16·9 km. per sec. while that of the centre of the system is in the neighborhood of + 38 km. per sec.

That there is a short period oscillation in the velocities would seem to be certain but a satisfactory period has not as yet been obtained. As the range in velocity of this short-period variation is small it has been possible by combining the velocities for each season into one mean to detect a long period variation. There are, unfortunately, a few gaps yet to be filled in but there seems no doubt of the general trend of the velocities over a curve whose period is about 9·6 years. The Yerkes' plates and our own are used in the grouped velocities following.

GROUPED VELOCITIES

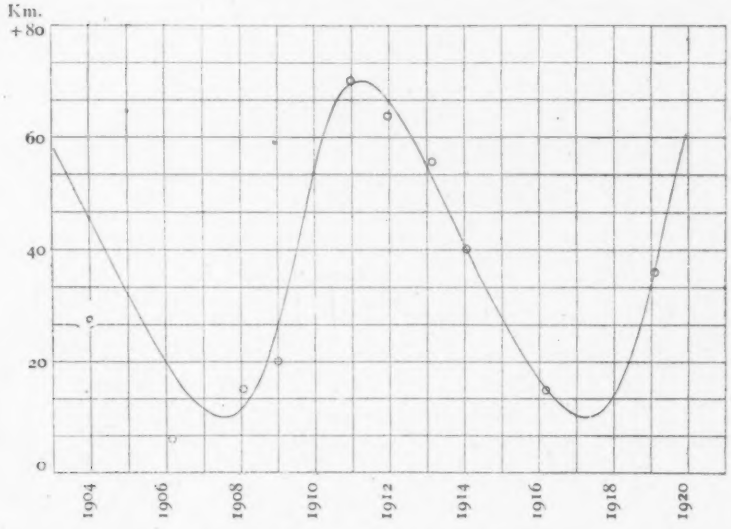
Observatory	Epoch	No. of Plates	Velocities	O − C
Yerkes	1903·95	2	+ 27·5	− 18
"	1906·16	1	6·	− 12
"	1908·07	1	15·	+ 3
"	1909·00	1	20·	− 6
Ottawa	1910·97	22	70·0	+ 0·4
"	1911·95	26	63·9	− 3·0
"	1913·13	17	55·6	+ 2·7
"	1914·05	5	40·1	0·0
"	1916·18	6	14·9	0·0
"	1919·09	7	+ 36·0	0·0

These velocities are plotted on the accompanying graph in which the curve shown represents the following elements. The curve was obtained graphically with only a few trials and no attempt has been made to improve the elements by a least squares solution.

PROVISIONAL ELEMENTS

$P = 9{\cdot}6$ years
$e = {\cdot}20$
$\omega = 285°$
$\gamma = +38{\cdot}45$ km.
$K = 30{\cdot}0$ km.
$T = 1909{\cdot}75$
$a \sin i = 1{,}417{,}000{,}000$ km.

The general character of the spectrum would seem to bear out this long period variation. The spectrum of the star which gives the fairly sharp lines whose measures are here recorded, and which may be called component 1, would seem to overlie that of one (component 2) consisting of faint and very broad bands, so broad in fact that they were never separated from the other. When the velocities for component 1 were at their maximum around 1911 the spectral lines were nearly at the extreme



RADIAL VELOCITY OF Nu GEMINORUM

red edge of the broad bands corresponding to component 2. The minimum is not so well recorded but apparently at that time there is more of the band showing to the red than to the violet. At intermediate points the principal lines are more nearly central on the bands. Minor variations, due possibly to the third component of the triple system, whose period is as yet undetermined, complicate matters but the foregoing, while given with a certain amount of reserve, seems to describe the general character of the spectrum. It is hoped to follow the star from time to time to more definitely determine the elements.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
February, 1919.

MAGNETIC RESULTS 1917

By G. Blanchard Dodge

DURING the ten seasons the magnetic survey of Western Canada has been carried out by the Topographical Surveys, over 200 stations have been occupied for Dip and Total Force observations. Over sixteen thousand observations have been made for declination alone, covering territory as far north as 60° N. latitude. These observations are so numerous as to preclude their publication. The results, however, have been compiled for over 9000 stations, and plotted on an isogonic magnetic map for 1917·0; which shows, also, the yearly rate of change for 1917·0.

All observations for Declination, Dip and Total Force have been reduced to International Magnetic Standard, by direct comparison at the beginning and end of each season with the magnetic standards at the Magnetic Observatory, Agincourt, of the Meteorological Service of Canada. The Declination observations have been reduced to mean-of-month by direct comparison with continuous declination magnetograms at the Magnetic Observatory, Meanook, Alberta, of the Meteorological Service of Canada.

Below are given the results of Dip and Total Force observations taken during the season of 1917. The observers were R C. Purser, D.L.S,, and E. S. Martindale, D.L.S.

Magnetic Results 1917

Station	Latitude	Longitude	Date	Declination	Dip	Hor. Int.	Total Int	Observer
	° ′	° ′		° ′	° ′	C.G.S.	C.G.S.	
South Junction	49 01	95 48	Aug. 12		77 15	·1386	·6284	R.C.P.
South Junction	49 02	95 48	July 31		77 20	·1378	·6285	"
Badger	49 12	95 58	Aug. 16	10 31	77 41	·1345	·6305	"
Menisino	49 05	96 06	Aug. 2		77 00	·1415	·6288	"
Sandilands	49 19	96 19	June 17-19	10 35	77 23	·1371	·6277	"
H. B. C. Cross Lake	54 37	97 46	Sept. 23 25	13 24	81 25	·0942	·6293	"
Deer Horn	50 46	98 04	Oct. 15		78 40	·1235	·6283	"
Stewart Lake	51 04	98 05	Nov. 17		78 47	·1220	·6268	"
Pebble Beach	51 00	98 30	Nov. 3-5	12 44	78 43	·1228	·6271	"
Erickson	50 29	99 54	June 9-10	16 40	78 02	·1301	·6279	"
Ethelbert	51 31	100 24	May 27-30	15 25	79 04	·1199	·6325	"
Neudorf	50 43	103 00	Sept. 5		79 36	·1352	·6300	"
Moose Jaw	50 24	105 32	June 8		76 59	·1397	·6203	E.S.M.
Davidson	51 16	106 00	Sept. 9		77 14	·1376	·6224	"
Limerick	49 40	106 17	Aug. 19		75 49	·1524	·6224	"
Riverhurst	50 54	106 52	Sept. 2		76 51	·1413	·6214	"
Morse	50 25	107 30	Sept. 14		76 27	·1452	·6198	"
Dinsmore	51 19	107 26	Sept. 23		76 57	·1396	·6186	"
Piapot	49 54	109 07	June 18	21 20	75 30	·1555	·6212	"
Alsask	51 23	109 59	July 8		76 30	·1448	·6202	"
Medicine Hat	50 02	110 41	July 19		75 29	·1549	·6184	"
Jenner	50 45	111 11	July 15		75 27	·1539	·6127	"
Coaldale	49 43	112 37	Nov. 1		74 37	·1611	·6074	"
Drumheller I.	51 28	112 42	May 20	24 59	75 52	·1493	·6114	"
Drumheller II.	51 28	112 42	May 27		75 51	·1500	·6134	"
Nobleford	49 52	113 05	Oct. 25		74 38	·1610	·6079	"

Topographical Surveys Branch,
Department Interior,
Ottawa, Canada,
January 24, 1919.

MEETINGS OF SOCIETY

At Toronto

February 11, 1919,—The Society met at 8 p.m. in the Physics Building of the University of Toronto, the President, Mr. A. F. Miller, in the chair.

Prof. Chant read a communication from Dr. Fernand Jacobs of Brussels, Belgium, on the resumption of astronomical work in that country after four years of war.

The death of Professor Edward Charles Pickering, of Harvard College Observatory, on Feb. 3, received the attention that such a calamity calls forth, and on motion by Prof. Chant, seconded by the Rev. Dr. Marsh, it was resolved that the President be requested to write to Prof. Bailey, expressing the regret of the Society at the death of Professor Pickering.

The following were elected members of the Society:—

E. L. Ruddy, Toronto.

Allan Graham McDonald, 21 Silver Ave., Toronto.

Harlow Shapley, Ph.D., Mount Wilson Solar Observatory, Pasadena, Cal., U.S.A.

Mathias Robert, 289 rue St. Catherine, Grand Mère, Que.

J. S. Taylor, Richwood, Ont.

The Librarian's monthly report showed that the Society had received forty-two publications in January.

Prof. Chant mentioned the good positions of the planets for observation at the present time; Mr. Miller referred to the sunspots that were appearing lately, and Mr. A. F. Hunter mentioned that some auroras of the first order had occurred since Dec. 10.

Prof. C. A. Chant gave the address for the evening:—"Are the Nebulae Separate Universes?" The subject he had chosen has required a great amount of marshalling of facts, some of which have only been ascertained recently, and with the help of the most powerful instruments. Only 2,000 stars at the most can be seen by the naked eye, and very few nebulae are discernible without telescopes. In 950 A.D. a Persian astronomer detected the great nebula in Andromeda with the naked eye, the only naked eye nebula. The telescope was invented in 1610, and in 1612 the first nebula was discovered by its use. Sir Wm. Herschel pursued the subject eagerly, and had 2,500 nebulae to his credit.

Prof. Campbell divides nebulae into three classes:—1. Formless nebulae. These have no shape, and many of them are in the Milky Way. 2. Spiral nebulae, and 3. Planetary nebulae, which have a bright nucleus or bright spot at the centre. There are also star clusters, which he classed with planetary nebulae. Prof. Chant showed on the screen a number of beautiful examples of the three kinds.

Sir John Herschel found that the better the telescope the more one can resolve the nebulae into stars, and it was inferred that all nebulae were stars in the ultimate analysis. This view prevailed until 1864, when Wm. Huggins put an end to it by applying the spectroscope to the study of the stars. Planetary nebulae give mostly spectra of three bright lines. There is a system or method in their distribution when they are mapped with reference to the Milky Way.

Our universe of stars is like a watch in shape, or a spiral nebula. The bright line nebulae, viz., the formless and the planetary ones, are around the Milky Way, but the spiral nebulae shun that region. This universe is estimated to be 10,000 light years across the narrow part, and 30,000 light years to the furthest part. The spiral nebulae are at much greater distances. They also have enormous speeds of translation. The difference they show was detected by Dr. V. M. Slipher and studied by the Lick and other observatories.

February 25,—The regular fortnightly meeting of the Society was held at 8 p.m. in the Physics Building of the University of Toronto, the President, Mr. A. F. Miller, in the chair.

A letter was presented from Prof. Bailey, acknowledging the receipt of the President's letter conveying the regret of the Society at the death of Prof. E. C. Pickering. A letter from Mr. F. S. Carrington, of Washta, Iowa, made several suggestions regarding the Handbook, and a number of important points in astronomical work.

An oral report of the business transacted at the meeting of the Council on Feb. 21st, was given, viz.:—That the Council concurred in what had been done regarding the change in the place of holding the public meetings, and passed $100 for settlement of rent account with the Royal Canadian Institute and appointed a small committee to negotiate terms for the continuance of the office and library in the Institute Building; that the Council also concurred in Prof. Chant's estimate of $2,000 for the JOURNAL, and $200 or $250 for the library in 1919; that, having fully considered the representations of Mr. C. A. Bigger, President of the Ottawa Centre, regarding better methods of reaching the public with astronomical information, lectures by local talent not having proved attractive at Ottawa, and they had decided that more could be done through the public schools, the Council resolved to obtain, if possible, an interview with the Minister of Education and appointed a committee of four to make the preliminary arrangements for the interview; that Rev. Dr. Marsh had received definite instructions from the Council regarding the telescope at Peterborough; that grants had been made to the divisional centres as follows: Montreal $150, Ottawa $150, Victoria, B.C., $75, and Winnipeg $50; that it had been resolved to take membership in the Belgian Society of Astronomy.

Prof. Chant referred in feeling terms to the recent death of Mr. G. G. Pursey, an old member of the Society, and one of its founders, and also to the death of Mr. Angus Sinclair, former librarian of the Society, and the chairman added a few remarks on the worth of these two pioneer members.

Prof. L. B. Stewart mentioned that on Feb. 16, at about 10 p.m. a fine meteor had appeared in the northwest sky and had parted in two when nearly overhead.

Mr. F. L. Blake made a few remarks on sun spots, which had been very few lately, the decrease showing an approach to the minimum.

Mr. J. P. Henderson had observed a small spot near the sun's equator, and Mr. Blake had seen a notched appearance made by a spot in the sun's edge a few days ago.

Mr. A. F. Miller made a few remarks on Jupiter and Mars, which bears a higher power in the telescope than Jupiter, and also on the stars in the constellation of Orion which is so conspicuous at this time of the year.

Mr. J. P. Henderson gave the address of the evening on "Time Distribution." He described the keeping of time as it developed from the earliest years in history, the sun always being the great time keeper. He described the sun dial and the clepsydra or waterclock, and mentioned the different varieties of the latter, its name meaning "water stealing away." The sun dial needed a clear day, but the clepsydra could be used on any day and at night, and on this account the Egyptians, who used it, began to make observations in astronomy, night observations then coming into existence.

In modern times the earth's surface has been divided into 24 time belts of one hour each. Toronto is in No. 5 of these belts, the time for which is sent from Arlington, Va., daily. Darien, in the Isthmus of Panama, sends out the time daily for the next time belt, and the signals from both stations are regularly heard at Toronto. The stars form the ideal method of getting the time, as they are never more than a point of light, and the sidereal clock can thus be readily checked by the stars. He described in detail the telegraphic and radio mthods of sending the time, a dot being used for each second, and the signal lasting for minutes. Telegraphic time signals are also sent out daily from McGill University, Montreal, over the entire C.P.R. System.

Mr. Henderson exhibited the equipment in the University

Physics Building for receiving the time signals by wireless, and the actual signals were received from Arlington, Virginia, at 10 p.m. and made quite audible to all who were assembled in the lecture room. These were followed by many weather predictions and baromter and wind data. The lecturer illustrated his address also by the use of many lantern slides.

A. F. HUNTER,
Recorder.

NOTES FROM

THE DOMINION ASTRONOMICAL OBSERVATORY

OTTAWA, CANADA

A NEW VARIABLE STAR

THE star 4 Aquilæ (B D + 1°3766) has been used as comparison star in determining the photographic magnitudes of Nova Aquilæ No. 3 and a second star, 5 Aquilæ (B D − 1°3559), was used also when the nova had become fainter than the fourth magnitude. At first the two determinations of the magnitude of the nova were in good agreement but an apparent discrepancy on August 17 was repeated on September 24, October 7 and November 10. A third star, BD + 0°4027, was measured and although the faintness of this star rendered the measures less reliable the discrepancy between it and 4 Aquilæ on the above-mentioned dates was quite evident. A period of 2.105 days fits all available observations but a further series of observations will be made before forming a mean light curve. The following table gives the magnitude differences between 4 Aquilæ and 5 Aquilæ, the former being the brighter.

Julian Day	Δm	Julian Day	Δm	Julian Day	Δm
2,421,320·643	0·90	*2,421,857·670	0·28	2,421,875·546	0·79
822.712	0·90	861·612	0·75	877·533	0·83
823·688	0·72	862·538	0·92	900·497	0·89
833 586	0·92	868·573	0·87	908·477	0·76
843·660	0·88	870·614	0·90	992.952	0·85
847·606	0·85	874·572	0·75		

*The plate on this date was rather badly fogged which may account for the apparently extreme change in brightness of 4 Aquilæ.

R. M. MOTHERWELL

NOTES FROM
THE DOMINION ASTROPHYSICAL OBSERVATORY
VICTORIA, B.C.

THIRD LIST OF SPECTROSCOPIC BINARIES

The following table contains a list of 20 binaries discovered in the course of the radial velocity work of this observatory. The first list of 12 binaries was published in the November, 1918, the second list of 18 binaries in the February, 1919, issues of the JOURNAL, which, with this list, makes 50 to date.

As in the first and second lists, the serial numbers are continued and the binaries are arranged in order of right ascension for convenience of reference. Notes in regard to the character of the spectrum and other remarks which are too long to be incorporated in the table, are given below the latter, the purpose being to make the data about each sufficiently complete to enable observers desiring to work at any of these binaries to decide on the character of the spectrum and its suitability for obtaining an orbit without making test plates.

For several stars measured here, other than the 50 in the three lists, there is probably a variation in the velocity but the observed range is so little greater than that likely to occur owing to error of determination as to make their binary character uncertain. As in such cases it would be impossible to determine orbits, and as, for radial velocity statistics, only the velocity of the centre of gravity of the system is required, this can be obtained with sufficient accuracy by securing say 10 or 12 plates of such stars over an interval long enough to cover more than one revolution of the system and the question as to whether they are binary or not is then not of so much moment.

In the table, column 1 gives the serial number of the binary. Column 2 gives the number of the star in Boss's Catalogue and in the Revised Harvard Photometry and its Right Ascesion and Declination for 1900. Column 3 gives the visual magnitude and spectral type from the Henry Draper Catalogue, the unpublished data being kindly supplied by Professor Pickering. Column 4 gives the date of the observation of each plate. Column 5 gives the Julian day and fraction of a day of the observation. Column 6 gives the measured radial velocity to tenths of a kilometre. Column 7 gives the respective quality of the individual plates as regards suitable exposure and development, but does not give any indication of the character of the lines, which is discussed in the supplementary remarks. The last column gives the discoverer, P standing for Plaskett, Y for Young.

No.	Star R.A. 1900 Dec. 1900	Type Mag.	Date	Julian Day 242	Radial Velocity	Quality	Discoverer
31	Boss 282	A5	Oct. 8‖18	1875·882	− 1·2	Good	P
	H.R. 361	5·6	" 27	1894·826	+ 22·9	"	
	01h 08m·5		Nov. 24	1922·762	+ 20·3	"	
	+ 7° 03′		Dec. 29	1957·660	− 2·7	Weak	
			" 29	1957·674	− 17·7	Fair	
			Jan. 7‖19	1966·697	+ 28·5	Good	
32	Boss 283	F8	Oct. 8‖18	1875·866	+ 46·4	Good	P
	H.R. 362	6·5	" 27	1894·842	+ 15·1	Weak	
	01h 08m·5		Nov. 24	1922·776	− 7·2	Good	
	+ 7° 03′		Jan. 7‖19	1966·682	+ 43·4	"	
33	.....	F5	Aug. 22‖18	1828·985	− 21·9	Good	P
	H.R. 407	6·1	Oct. 8	1875·911	− 1·7	"	
	01h 20m·1		" 20	1887·806	− 15·5	"	
	+ 23° 00′		Nov. 24	1922·794	− 18·7	"	
34	Boss 606	A2	Oct. 6	1873·906	+ 2·0	Good	P
	H R. 782	5·4	" 19	1886·894	− 10·6	"	
	02h 34m·8		" 27	1894·869	+ 24·7	"	
	+ 26° 38′		Nov. 24	1922·837	+ 15·9	"	
35	.....	B9	Sept. 11	1848·958	− 33·1	Good	Y
	H.R. 894	5·9	Nov. 22	1920·815	− 22·5	"	
	02h 53m·8		" 22	1920·830	− 11·4	Weak	
	+ 37° 45′		Dec. 20	1948·723	− 8·1	Good	
			" 20	1948·739	− 4·8	"	
36	Boss 787	A0	Nov. 20	1918·866	− 9·7	Fine	Y
	H.R. 1041	5·6	Dec. 16	1944·769	+ 19·8	"	
	3h 22m·0		Jan. 10‖19	1969·701	+ 6·4	"	
	+ 33° 28′						
37	Boss 809	A0	Nov. 22‖18	1920·870	− 20·0	Good	Y
	H.R. 1078	5·8	Dec. 16	1944·782	+ 20·5	"	
	3h 26m·9		Jan. 10‖19	1969·715	+ 103·9	"	
	+ 39° 34′		" 29	1988·647	− 79·1	"	
38	Boss 836	A0	Oct. 8‖18	1875·926	+ 42·1	Good	P
	H.R. 1118	6·2	" 27	1894·901	− 14·7	Fair	
	3h 34m·8		Nov. 25	1924·856	− 19·6	Good	
	+ 25° 00′		Dec. 10	1938·801	+ 43·1	"	
39	Boss 943	A0p	Dec. 20	1948·812	+ 12·8	Good	Y
	H.R. 1268	5·3	" 30	1958·731	+ 1·4	"	
	04h 00m·5		Jan. 29‖19	1988·665	− 17·0	"	
	+ 27° 21′		Feb. 14	2004·664	− 7·9	Fair	
40	Boss 1004	F0	Oct. 20‖18	1887·885	+ 67·4	Fair	P
	H.R. 1351	5·6	Nov. 26	1924·881	+ 59·8	Good	
	04h 14m·3		Dec. 10	1938·806	+ 12·5	"	
	+ 13° 48′		Jan. 19‖19	1978·749	+ 12·5	"	
			Feb. 2	1992·597	+ 52·4	"	

No.	Star R.A. 1900 Dec. 1900	Type Mag.	Date	Julian Day	Radial Velocity	Quality	Discoverer
				242			
41	Boss 1085	B9	Oct. 30‖18	1897·889	+ 1·8	Good	Y
	H.R. 1471	5·7	Nov. 1	1899·863	- 16·2	"	
	04h 32m·4		Dec. 30	1955·775	- 53·2	"	
	+20° 30′		Jan. 6‖19	1965·765	+ 6·0	"	
42	Boss 1273	B9	Nov. 4‖18	1902·921	- 1·3	Good	Y
	H.R. 1750	6·3	Dec. 20	1948 876	+ 24·5	"	
	5h 14m·7		" 30	1958·801	+ 36·6	"	
	+27° 51′		Jan. 6‖19	1965·782	- 28 8	"	
43	Boss 1336	B9	Oct. 8‖18	1875·973	+ 0·1	Good	P
	H.R. 1847	5·5	" 19	1886·905	+ 7·0	"	
	5h 26m·4		Dec. 10	1938·879	+ 7·6	"	
	+16° 59′		Jan. 7‖19	1966·860	+ 17·8	Weak	
			" 30	1989·709	+ 26·0	Fair	
			Mar. 2	2020·640	+ 18·0	Good	
44	Boss 1337	A	Oct. 19‖18	1886·977	+ 6·9	Good	P
	.....	6·8	Dec. 10	1938·896	+ 28·0	"	
	5h 26m·4		Jan. 30‖19	1989·724	+ 23·2	Poor	
	+16° 59′		Mar. 2	2020·656	+ 21·3	Good	
45	Boss 1369	B8	Nov. 4‖18	1902·958	+ 0·5	Good	Y
	H.R. 1902	5·7	an. 10‖19	1969·728	+ 10·8	Fair	
	5h 30m·9		" 10	1969·740	+ 14·7	Good	
	+26° 52′		" 29	1988·712	+ 8·8	Fair	
46	.....	A0	July 12‖18	1787·896	+ 1·7	Good	Y
	H.R. 8422	6·4	" 30	1805·889	- 1·5	"	
	22h 01m·8		Sept. 5	1842·841	+ 9·6	Poor	
	+44° 37′		Nov. 1	1899·566	- 23·6	Good	
47	.....	B3	July 12	1787·918	-143·0	Good	Y
	H.R. 8427	6·2	Aug. 5	1811·876	- 94·1	"	
	22h 02m·0		Sept. 16	1853·747	+ 10·6	Weak	
	+47° 45′		Nov. 4	1902·676	- 82·1	Good	
48	.....	B5	July 16	1791·968	- 39·9	Fair	Y
	H.R. 8800	6·6	" 30	1805·950	+ 25·5	"	
	23h 02m·7		Sept. 5	1842·898	+ 49·2	"	
	+45° 33′		Nov. 20	1918·644	- 57·9	Fine	
			Dec. 23	1951·567	-128·7	Weak	
49	Boss 6070	A0	Nov. 24	1922·665	- 13·3	Good	P
	H.R. 8960	6·2	" 30	1928·610	- 34·1	"	
	23h 32m·6		Dec. 15	1943·623	- 1·8	"	
	+16° 17′		" 29	1957·624	- 32·8	"	
50	Boss 6072	A0	Nov. 24	1922·678	- 24·2	Good	P
	H.R. 8963	5·4	" 30	1928·622	- 39·8	"	
	23h 32m·9		Dec. 15	1943·637	- 36·8	"	
	+17° 51′		" 15	1943·647	- 35·5	"	
			Jan. 6‖19	1965·600	- 16·6	Fair	
			" 6	1965·608	- 5·1	Good	

No. 31. This spectrum though containing numerous metallic lines is difficult of measurement as they are broad, diffuse and lacking in contrast. The measures in general depend chiefly on the hydrogen lines and on a strong though broad K and although the range is not great there is no doubt of its reality.

No. 32. This star of spectral type $F8$ and sharp lines was measured on the spectro-comparator and as in all stars of this type, the measures are reliable.

No. 33. This spectrum of type $F5$ was also measured on the spectro-comparator and both it and No. 32 are of excellent quality for measurement.

No. 34. In addition to the strong and rather broad hydrogen lines and K there are a number of fairly well defined metallic lines and as the measures exhibit good internal agreement, the velocities are reliable.

No. 35. Hydrogen $H\gamma$ and $H\delta$ and the calcium K line and magnesium 4481 are all the lines measurable in this star. K and 4481 are narrow but faint. The hydrogen lines are rather broad but have a fairly sharp core.

No. 36. This is a fine spectrum for measurement. There are very many narrow metallic lines in addition to a narrow K line and silicon 4128 and 4131.

No. 37. Numerous lines are present in the spectrum but they are not of very good quality for measurement. Additional plates will be obtained of this star to obtain the orbital elements.

No. 38. The character of spectrum and the quality of the lines for measurement are very similar to No. 34 and measures are equally reliable.

No. 39. The lines are unusually fine and narrow. 4128, 4131, K, $H\delta$, $H\gamma$, 4233, 4481 were all that were measured. The silicon lines are strong while K and 4481 are very faint but sharp.

No. 40. The large number of metallic lines common to type F stars are, however, not as well defined as usual and are too

broad to be suitable for measurement on the comparator. Measures of about 15 lines on each plate with the micrometer microscope exhibit good internal agreement.

No. 41. Five lines were measured in the plates of this star. The hydrogen lines, calcium K and both 4471 and 4481. They are of fair quality only.

No. 42. Spectrum much like that of No. 41. K is very faint and the other lines of not very good quality. 4471 was not measured.

No. 43. This star given as $B9$ in Harvard is, however, of somewhat earlier type as the helium lines are fairly strong, He, 4476 being of nearly equal intensity with Mg 4481. An average of 10 lines fairly well defined make the velocities obtained trustworthy. The magnitude given as 5·49 in Harvard must refer to the combined magnitudes of this and its companion No. 44, 10″ away, as the magnitude of this star is nearer 6·5 than 5·5.

No. 44. This star, of somewhat later type than the preceding, is not so suitable for accurate measurement as only the broad hydrogen lines and a narrow sharp K can be measured. However the internal agreement is good, and there is no doubt of the reality of the variation as the change in position and the accuracy of the measurement of the sharp K is sufficient to establish this.

No. 45. The spectrum of this star is very similar to that of No. 39, and though the published range is rather small there is no doubt of the reality of the variation. 4233 was not measured.

No. 46. Hydrogen, calcium, magnesium lines are all that were measured in the spectrum. They are of fair quality.

No. 47. The usual lines of a star of this type are present in the spectrum. They are of rather poor quality. The calcium K line gives apparently a constant or nearly constant velocity.

No. 48. On the majority of the plates of this star only $H\gamma$ and 4388 and 4471 were measurable. But on the plate taken

November 20 the usual helium lines 4026, 4144 are also quite measurable. The calcium *K* line was measured on two plates and yields a constant velocity.

No. 49. This star has beautifully narrow sharp metallic lines in addition to the hydrogen series and the measures are hence very satisfactory and reliable.

No. 50. This star of the same type as the preceding has only the hydrogen series, Mg 4481 and *K* measurable, and all of them are rather broad. Although the two last plates do not agree very closely, the internal agreement among the lines in the several plates is sufficient to establish the variable velocity.

J. S. PLASKETT,
REYNOLD K. YOUNG.

VICTORIA, March 7, 1919.

NOTE.—Four of the binaries in the above list are especially interesting in that they compose two visual doubles and it seems worth while to give some details about them. They are Nos. 31, 32 and Nos. 43, 44. Nos. 31, 32, Pisces, Boss 282 and 283, whose magnitudes and spectral types are given above, are separated by about 24″ and evidently have a common proper motion, as their distance and position angle have not appreciably changed in the last 80 years. Burnham discovered an eleventh magnitude companion to the fainter of the pair, Boss 283, which is distant about 0″·9, and the measures of this close pair since then have shown, as he says, "that there is probably slow orbital motion." He further says :— "These three stars undoubtedly constitute a vast physical system."

The measures of six spectra of the brighter, preceding star, and of four spectra of the fainter, following star show that this system is even more complicated than Burnham supposed, for the radial velocity of each varies, each is a spectroscopic binary, and the system consists of five stars instead of three. The details

of these measures are given in the list of binaries, but it may be of interest to re-state that the spectra obtained of the brighter star, whose magnitude is 5.57 visual, 5.71 photographic, and spectral type A5, have shown a range of 40 km., while of the other, whose magnitude is 6.49 visual, 6.99 photographic and spectral type F8. the range so far observed is upwards of 50 km.

Nos. 43, 44, Boss 1336, 1337 in Taurus, are separated about 9″·5 and are slowly approaching one another, their separation having diminished about 0″·4 since 1831, at the rate of about 0″·5 per century. It is, of course, not possible to say that they are physically connected but owing to their similar types and magnitude and their comparative proximity in the sky it is not at all improbable. This probability is further strengthened by the fact that apparently the mean velocities, so far as can be determined from the few plates available, only differ slightly from one another.

These two pairs are further interesting in that the number of visual doubles of which both components are known to be spectroscopically double are very limited in number in the sky. So far as known, although I have not all available literature at hand, Castor and Mizar, besides these two pairs, are the only examples.

J. S. Plaskett.

Dominion Astrophysical Observatory,
Victoria, B,C., March 7, 1919.

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

February, 1919

Temperature– The mean temperature of the month was decidedly above average from eastern Manitoba, over Ontario and Quebec to the Maritime Provinces, with the largest positive departures, nearly 10°, near Lake Superior. In Saskatchewan it was nearly average throughout the Province, while in Alberta it was above average in the south and below in the north. In British Columbia it was very generally below, with the largest negative departures in the north.

Precipitation—The precipitation was very generally less than average in all the Provinces. In Southern Ontario and Southern Nova Scotia it was chiefly rain, while in the Western Provinces, and in the northern districts of the older Provinces, it was almost wholly snow.

Temperature for February, 1919

Station	Ferbuary		Station	February	
	Highest	Lowest		Highest	Lowest
Yukon			Kenora	32	-34
Dawson	38	-40	Kinmount	41	-12
British Columbia			Kingston	46	8
Atlin	33	-40	Kitchener	51	5
Agassiz	49	16	London	53	8
Barkerville	41	-21	Lucknow	46	- 6
Kamloops	47	0	Markdale	41	- 4
New Westminster	52	21	North Gower	44	-10
Prince Rupert	57	24	Oshawa	47	10
Vancouver	50	25	Ottawa	37	- 7
Victoria	51	27	Paris	55	6
Western Provinces			Parry Sound	42	-10
Battleford	35	-50	Peterboro'	44	0
Calgary	54	-23	Port Arthur	37	-20
Edmonton	43	-37	Port Burwell	46	9
Medicine Hat	56	-25	Port Dover	38	8
Minnedosa	36	-42	Port Stanley	42	10
Moose Jaw	43	-33	Queensborough	41	- 7
Oakbank	29	-35	Ronville	40	-19
Portage la Prairie			Southampton	45	1
Prince Albert	34	-46	Sundridge		
Qu'Appelle	39	-50	Stonecliffe	38	-22
Regina	36	-40	Stony Creek	57	8
Saskatoon	35	-48	Toronto	53	10
Souris	38	-37	Uxbridge	45	- 1
Swift Current	40	-20	Wallaceburg	53	9
Winnipeg	30	-30	Welland	55	5
Ontario			White River	42	-31
Agincourt	47	11	*Quebec*		
Aurora	42	2	Brome	38	-17
Bancroft	37	-14	Father Point	36	-10
Barrie	42	0	Montreal	35	6
Beatrice	41	-11	Quebec	33	- 8
Bloomfield	40	5	Sherbrooke	39	-11
Brantford	49	5	*Maritime Provinces*		
Chapleau	50	-26	Charlottetown	38	10
Chatham			Chatham	38	- 6
Clinton	40	4	Dalhousie		
Collingwood			Fredericton	41	-16
Cottam	46	11	Halifax	42	10
Georgetown	48	5	Moncton	39	0
Goderich			St. John	40	5
Gravenhurst	43	-15	Sussex	39	-12
Grimsby	43	8	Sydney	42	8
Guelph			Yarmouth	40	14
Haliburton	42	-17			
Huntsville	36	-18			

MAGNETIC OBSERVATIONS

The values of the magnetic elements for Agincourt and Meanook observatories which have been published in the JOURNAL from month to month are the results of a preliminary analysis of the data obtained and it has been considered advisable to delay the publication of the monthly values until after the close of the year and to then give a full year's results together, after the final reductions of observations for the year have been made.

Any remarkable disturbance occurring during the year will be referred to briefly by a note in the JOURNAL immediately following its occurrence.

No large disturbances were recorded at Agincourt during January, nevertheless there were four which were quite noteworthy on account of their sudden commencement and their duration.

The accompanying table gives particulars of these disturbances. At Meanook these disturbances were all of fairly large amplitude.

Sudden beginning. 75th Meridian Time			Range				Ending	
			H	Z	Ag. D	Mc. D		
	h	m	γ	γ	′	′		h
January 3,	13	10	267	195	81·4	165·4	January 6	
12,	18	23	64	96	29·5	94·5	13	18
13,	19	56	304	169	64·1	113·3	14	16
31,	5	40	166	93	54·1	115·7	February 1	20

In February a very large disturbance began during the afternoon of the 27th with small oscillations, increasing in magnitude up to midnight, when the greatest departures from normal occurred. By 2h, 75th Meridian Time, of the 28th the maximum of the storm was over although it continued as a moderately active disturbance until March 2nd. The ranges recorded at Agincourt were for H, 440γ; for Z, 272γ; and for D, 64′·5; and at Meanook for D, 136′·3.

W. E. W. J.

Earthquake Records by the Milne Seismograph

TORONTO

Sir Frederic Stupart, Director.

P.T. = Preliminary Tremors. S. = Secondary Waves. L.W. = Large Waves. A.C. = Air Currents. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1919	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m	h m	h m	h m	h m	mm	
1957	Feb. 2		20 24·4	20 26·8	20 28·4	Micros.	1·4	Micros make early phases doubtful.
1958	" 12			13 24·9?	13 35·5?	Micros.	0·3	Micros going on.
1959	" 15			2 39·3	2 42·4	3 00·0	0·6	Marked gradual thickening.
1960	" 16			16 07·0?		16 12·0?	0·2	Small micros going on.
1961	" 22			4 58·9?) 5 10·2)		Micros.		Small micros going on.

Boom period 18 seconds. Pillar inclination 1mm. = 0″·45.

VICTORIA, B. C.

F. N. Denison, Superintendent.

No.	Date 1919	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m s	h m s	h m s	h m s	h m s	mm	
1960	Feb. 2	20 24 27?		20 29 22?	20 31 49	20 45 35	0·2	
1961	" 12	12 59 32?			13 28 33	14 06 59	0·3	
1962	" 16	16 05 38?		16 07 07	16 09 06	16 14 33	0·2	
1963	" 22	4 51 17?			4 56 42	?	0·1	

Boom period 18 seconds. Pillar inclination 1mm. = 0″·54

THE EARTHQUAKE OF DECEMBER 6TH, 1918.

THIS disturbance was most severely felt on the west coast of Vancouver Island, and was well recorded here on both the E-W and vertical seismographs. The first wave on the latter instrument reached here at 8.41.44 G.M.T. and S. at 8.42.28, Max. 8.42.40, Max. Amp. μ 490. The distance to the origin was 320 km., or 200 miles. From these measurements and others obtained from the Toronto, Ottawa and Saskatoon seismographs the epicentre is placed at longitude 127° 20′ west and latitude 49° 30′ north. This position is 37 miles off Estevan Point and about the same distance from Nootka light, both of these light houses feeling the maximum effects of these seismic waves.

Referring to the Dominion Atlas of Canada (1915, p. 53), we find the above location of this quake lies where the ocean depths suddenly increase and also just north of a marked submarine promontory, while the quake which was recorded here at 12.03.32 appears to have occurred just to the south of this marine promontory and on the same line where the marine depths increase. The latter quake was of less intensity than the first and was not generally felt, though doubtless occurring on the same line of weakness (Long. 127° 00′ W., Lat. 49° 10′ N.)

In order to obtain detailed information respecting the extent and effects of these quakes, circular letters were forwarded to a number of our observers in Western B.C., and the following interesting notes have been received:—

Estevan Point:—(epicentrum distance 37 miles)—Most pronounced rocking movement, causing the great 110 foot light tower to sway sufficiently to tip some of the mercury out of the basin containing the revolving light. Time of beginning not exactly known, duration about one minute, followed at 4 a.m. (Pac. Standard) by another and weaker shock.

Nootka Lighthouse (distance 35 miles)—Quake felt as severely as at Estevan, but light tower being much lower, the effect was considerably less.

S.S. Gray, lying at Kyuquot (distance 35 miles north)—The captain reported experiencing several severe blows against the ship as if struck

by a large whale or caused by an engine explosion. Felt also severely on land.

Clayoquot (distance 67 miles S.E.)—Felt severely; no damage.

John Grice—At Kennedy Lake Hatchery, the salmon eggs contained in trays were piled on the north and south sides, indicating N.S. wave action.

Port Alberni, B. P. Allard (distance 117 miles, S.E.)—The observer and several others facing each other east and west report the house rocked so much that their chairs appeared to rock 6 inches out of the vertical. Shock not felt as much at sea-level, altitude of above being 250 feet.

Uclulet, E. Lee (90 miles S.E.)—Strong vibrations caused several weak piles at wharf to break off.

Victoria (200 miles S.E.)—Was generally felt and was most pronounced in the upper portions of the high buildings, while at the Meteorological Observatory on Gonzales Heights, the effect was not sufficient to stop any of the clocks, or awaken observer. No record on tide guage.

Sooke Harbour, J. A. Murray (180 miles S.E.)—Effect very slight. Out of 15 persons interrogated, only two felt any movement.

Quatsino, B. W. Leason (72 miles N.)—Duration one-half to three minutes; house appeared to move quickly up and down; no damage.

Alberni, Beaver Creek, S. Bayne (116 miles E.)—Duration about two minutes; house creaked audibly and plaster cracked considerably; everyone aroused. Second quake at 4 a.m., very slight.

Shawnigan Lake, Col. Eardley-Wilmot (175 miles S.E.)—Duration about one minute; pictures, doors and windows rattled; no damage.

Cowichan, C. F. Walker (170 miles S.E.)—Some people awakened by houses shaking at about 00:45 a.m.

Ladysmith, J. Stewart, (158 miles E.)—Commenced at 00:40 a.m.; slight movement. Some seconds later house shook violently twice; no damage.

Nanaimo, L. Ross (155 miles)—Those awake at time felt a slight shock at about 00:45 a.m.

Nanoose Bay, F. G. Claudet (145 miles E.)—At 00:45 a.m., duration 30 seconds; two shocks, one short, the second one much longer and shook articles off shelves. The above not felt by observer at Northwest Bay, though awake at the time.

Cape Lazo, H. W. Bayley (110 miles east)—Duration one minute, time 0:45, direction W.E.; rocking motion, clocks stopped. At end of quake,

after three seconds lull, a renewed swaying motion lasted four to five seconds. A second quake occurred at 4 a.m., less violent, and lasted 30 seconds.

Van Anda, Texada Island, Wm. Kirkness (125 miles E.)—Felt by those awake, caused a rocking movement and rattling of furniture and windows. Not felt by observer, who was travelling on a road near Van Anda at the time; duration about 40 seconds.

LOWER MAINLAND

Vancouver, T. S. H. Shearmen (185 miles E.)—Four or five shocks were reported; possibly 1 minute and 15 seconds covered duration of these, direction from the westward. The noise resembled the rumbling of a distant automobile or sudden gust of wind. Clocks were stopped in some cases. The master clock of the Vancouver Block (the tallest building in the city) stopped at 00:41, while a large clock on the main floor of the Post Office stopped 00:45:46 sec. Possibly the great height of the Vancouver Block clock would cause it to stop during one of the faint preliminary shocks. The regulator clock at Messrs. Henry Birks stopped at 00:43:10 sec., and was not one second in error. This clock is thirty feet above the ground level, and near the Vancouver Block. Loose articles were thrown from shelves, etc.

Chilliwack, J. H. Chapman (240 miles E.)—Very light quake felt by a few; no damage.

Kelowna, George R. Binger (355 miles E.)—Heard a curious noise as he was writing at 00:40 a.m. on the 6th; this continued, and aroused his wife, who also heard it, but no tremor was felt. Other people heard this noise and several clocks were stopped. At the C.P.R. wharf the express agent felt the building sway and the files on the walls oscillated. He also heard the noise. The wharf is built on piles.

From the above information this quake appears to have been felt within a radius of about 300 miles, very slight along the Lower Fraser Valley, and if the Kelowna time is incorrect the seismic waves appear to have become accentuated in the Okanagan Lake District. It is possible, however, that a slight local quake may have occurred there a few minutes before the Vancouver Island seismic waves could reach that district. It is interesting to note that this quake was not felt to any marked degree in parts of the southern and eastern sections of Vancouver Island, while at the City of Vancouver on the mainland the effect

appears to have been more pronounced, as is shown by the number of clocks stopped there, and at New Westminster and other adjacent parts of the Fraser River Valley the quake was scarcely noticed. It is also curious that the clock in the high Vancouver Block should have stopped only three seconds after the quake occurred on the west coast, the time at point of origin being 8.40.57 G.M.T. Though assured the time of this clock was correct, measurements show that the first tremors would reach the Vancouver Block only a few seconds before they were recorded on the Victoria seismograph at 8.41.44, and the first surface waves at 8.42.00, the earliest time one might expect this high tower clock to stop.

F. Napier Denison.

Meteorological Observatory,
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Victoria, B.C.

ASTRONOMICAL NOTES

[The paper by Dr. Shapley from which this extract is taken supports the view that our galactic system includes all the visible Universe; in other words, he opposes the "island universe" hypothesis.—C. A. C.]

THE ARRANGEMENT OF THE SIDEREAL UNIVERSE.—A fairly definite conception of the arrangement of the sidereal system evolves naturally from the observational work discussed in the preceding Contributions. We find, in short, that globular clusters, though extensive and massive structures, are but subordinate items in the immensely greater organization which is dimly outlined by their positions. From the new point of view our galactic universe appears as a single, enormous, all-comprehending unit, the extent and form of which seems to be indicated through the dimensions of the widely extended assemblage of globular clusters. The fundamental nature of the galactic plane, in the dynamical structure of all that we now recognize as the sidereal universe, is manifested by the distribution of clusters in space. Near this plane lie the celestial objects that we customarily study. The open clusters, the diffused and planetary nebulæ, the naked-eye stars, most variables, the objects that define and compose the star streams—all of these appear to be far within a relatively narrow equatorial region of the greater galactic system, a region in which such forces are at play that compact clusters of great mass apparently cannot form or exist. The Orion nebula and even the Magellanic clouds are miniature organizations in this general scheme, and undoubtedly are dependents of the galaxy.

The adoption of such an arrangement of sidereal objects leaves us with no evidence of a plurality of stellar "universes." Even the remotest of recorded globular clusters do not seem to be independent organizations. The hypothesis that spiral nebulæ are separate galactic systems now meets with further difficulties. So long as the high velocities of nebulæ were unapproached by the

motions of other objects and the maximum luminosity attainable by stars was beyond estimate, and so long as the diameter of the galactic system was thought to be only a thousand light-years or so, we had a fairly plausible case for the "island universe" hypothesis. But now we must consider radial velocities of several hundred kilometers a second as quite possible for objects in our own system; we must assume a moderate upper limit of luminosity, perhaps even for the most massive of novæ; and any external "universe" must now be compared with a galactic system probably more than three hundred thousand light-years in diameter. As seen from the centre of the galactic system, globular clusters would be distributed in the sky much as the spirals are when observed from the earth.

It is probable that the further accumulation of observations will modify to some extent the views outlined above and discussed more fully in the following pages. The present data may in some cases be susceptible of alternative interpretation, or possibly the conclusions may be questioned in the belief that the material is insufficient. But the greater part of the hypothesis proposed is merely the most direct and simple reading of recent observations.

The suggested plan of the galactic system may be concretely formulated through the following series of propositions; some of them are later amplified in so far as seems necessary; for others the discussion of preceding contributions will suffice. A few of the statements are obvious corollaries, while those designated B and F, in some of their details, may be less easy to maintain. Taken altogether they attempt to establish a general idea of the arrangement, extent, and constituency of the system of stars and nebulæ.

A. The globular clusters are a part of the galactic system and knowledge of their distances seems at present to afford the best way to fathom the system.

B. The system of globular clusters, which is coincident in general, if not in detail, with the sidereal arrangement as a whole, appears to be somewhat ellipsoidal. The longest axis of the ellipsoid lies in the galactic plane and passes the sun at a distance of approximately three thousand parsecs. Its nearest point is in galactic longitude 240°, nearly coincident with the direction of

the centre assigned to the local system of stars.

C. The centre of the sidereal system is distant from the earth some twenty thousand parsecs in the direction of the constellation Sagittarius; it lies in the galactic plane, which dynamically and statistically appears to be the symmetrical plane of the entire sidereal universe as now known. As seen from the sun the thinnest part of the Milky Way lies in Gemini, Taurus, and Auriga—a region rich in bright open clusters close to the galactic plane.

D. The axes of the system in the galactic plane and perpendicular to it may not differ greatly; but the gravitationally important equatorial segment, which apparently contains most of the stars, is at least thirty times as extended in the plane as at right angles thereto.

E. The equatorial region appears to be uninhabitable by compact systems, such as globular clusters, notwithstanding the greater abundance there are of stellar material.

F. The stars in the neighborhood of the sun (practically all that go into our catalogues of spectrum, position and motion) appear to compose (1) a large, open, moving subordinate group, and (2) a part of the surrounding and interpenetrating star fields of the equatorial segment of the greater galactic system. The centre of the local system is in the direction of the constellation Carina, nearly at right angles to the direction of the centre of the general galactic system, but less than one two-hundredths as far away. The plane of symmetry and condensation of the local cluster is inclined to the galactic plane about 12°; the centre of the cluster is north of the galactic plane, and the sun is north of both planes.

G. The volume of space occupied by stars brighter than the sixth apparent magnitude, some of which, being absolutely very bright, are extremely distant as compared with the majority of naked-eye stars, is at most only a hundred-thousandth of the volume occupied by the other parts of the galactic system.

In order to show where the earlier working hypotheses stand with respect to the interpretation now offered, it may be of interest to note the development, during the course of this work on

clusters and variable stars, of the ideas concerning the relation of globular clusters to the galactic organization. Until the last year or so most students of stellar problems believed rather vaguely that the sun was not far from the centre of the universe, and that the radius of the galactic system was of the order of 1000 parsecs. From the earlier observational data Seelinger and Newcomb derived a fairly central position for the sun. Hertzsprung in 1906 estimated the "Dimensionen" of the visible Milky Way system to be of the order of 2000 parsecs, and some years later Walkey, from consideration of extensive distributional data, estimated a distance of about seventeen hundred parsecs for the galactic main stream. In 1914, referring to the apparently lens-shaped sidereal system, Eddington wrote, "There is little evidence as to the sun's position with respect to the perimeter of the lens; all that we can say is that it is not markedly eccentric"; and the diameter of the whole system (possibly excluding the peripheral ring of galactic clouds) was placed at some two or three thousand parsecs, with emphasis on the uncertainty. For a later computation Eddington assumed the distance of the Milky Way to be 2000 parsecs.

The work on the hypothetical parallaxes of Cepheids and O-type stars by Hertzsprung, and of eclipsing binaries and Cepheids by Professor Russell and the writer, began to give concrete numerical expression to the distances of the remote galactic objects, and in 1914 we have the statement: "Our 'universe' of stars must be some thousands of light-years in diameter," but the computed radius of 2500 parsecs was reduced to 1200 by allowing for a presumably reasonable and necessary scattering of light in space. The necessity for such a correction seems now definitely to have vanished, but the general conception of the size of the stellar system has not materially changed.

In view of these prevailing beliefs, the working hypothesis that a globular cluster is a wholly distinct stellar system was quite appropriate when in 1915 it was found that the Hercules cluster (Messier 13) is possibly several hundred parsecs in diameter. It appeared then that the galactic system might be a large but sub-

ordinate unit, eccentrically situated with respect to the greater aggregation of globular clusters. The great distances of the clusters, the similarity of their stars, in many properties, to those of the galaxy, and finally the discovery of galactic planes in a number of them, tended to emphasize further the comparability of clusters and our own surrounding galactic system of stars.

Two difficulties stood in the way of a definite hypothesis—the comparatively high condensation at the centres of globular clusters and the uncertainty relative to the constituency and distances of open clusters in the galactic clouds. The study of Messier 11 and of the dense star clouds in its neighborhood revealed the presence of faint blue stars—objects which, unless abnormal in size, must be quite similar in absolute magnitude to members of Charlier's cluster of B-type stars, but at least twenty times as distant as the limits of his group.

Evidence was also found that the Milky Way clouds near Messier 11 were greatly extended in the line of sight. For a number of other parts of the Milky Way the study of stars in clusters and clouds indicate analogous conditions, and the conviction grew that the galactic system had an extent of at least 15,000 parsecs along its plane. This left little occasion for the direct comparison with globular clusters, the diameters of which were found by further study to be of the order of 150 parsecs. As a consequence, their relation to the general system was quite uncertain until the present determination of parallaxes and the discussion of the distribution in space indicated the position of globular clusters in the arrangement of sidereal objects and suggested that the actual diameter of the galactic system is of the order of 100,000 parsecs.

According to the present view of the galactic system, the phenomenon of the Milky Way is largely an optical one. Although the existence of local and occasionally very extensive condensations of Milky Way stars is not denied, the conception of a narrow encircling ring is abandoned. The Milky Way girdle is chiefly a matter of star depth, and its long recognized weakness between longitudes 90° and 180° is now taken to be a reflection of the eccentric position of the sun.—HARLOW SHAPLEY, Contributions from the Mount Wilson Solar Observatory, No. 157. [A parsec equals about three and one-third light-years].

J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

RECENT MAGNITUDES OF NOVA AQUILÆ NO. 3

In personal letters received from the Dominion Observatory, Ottawa, some recent determinations of the magnitudes of the nova are given.

From his photographs Mr. R. M. Motherwell obtains the following magnitudes, using B.D. 0°·4027, with magnitude 6·05, as comparison star :

February	2	6·03
"	10	6·10
"	17	6·10

Mr. W. E. Harper's visual estimates are :

February	10·95	G.M.T.	6·1
"	19·91	"	6·4
March	13·92	"	6·8

In Harvard Bulletin 679, Barnard's estimate of the magnitude on the morning of January 24 is given as 6·0.

Mr. Harper states that a spectrogram taken on the morning of March 14 " shows emission N_1 (λ5007), N_2 (λ4959) and λ4363 joined on to $H\gamma$. The $H\beta$ emission, strange to say, is absent. The N_1 and N_2 are narrow and well-defined, the former about three times as intense as the latter. $H\gamma$ + λ 4363 is one broad band fainter than N_2 and ' eaten into ' by absorption."

At a later date, when the nova has fallen still lower in brightness, it is hoped to print a fuller account of the star derived from observations at the Dominion Observatory.

GEODETIC SURVEY REPORT.

The first annual report of the Canadian Geodetic Survey since its separation from the other astronomical branches of the Department of the Interior has just been issued. It contains a general sketch of the nature of its objects and organization by the Superintendent, Mr. Noel Ogilvie; and then a brief account of the various operations of the Survey in 1917, by the officers immediately in charge. Included are numerous illustrations and maps. On page 8 is shown the 147-foot tower near Chatham, Ont., and included in pages 34 to 48 are maps giving the positions of the towers all over the country. These odd structures have been a source of curiosity to many people. Then there are illustrations of the apparatus used, of the men at work and of the offices at Ottawa. Besides, there are maps of Canada showing the triangulation completed, data available for publication, and also the precise levelling of the Survey. Indeed there is much in the report which is of interest to the readers of the JOURNAL, and I presume copies will be sent on request to the Superintendent. It is very desirable that the people should become acquainted with the scientific work carried on in our country.

MESSAGES TO THE STARS.

> "Science reaches forth her arms
> To feel from world to world, and charms
> Her secret from the latest moon."

Many people have recently been reading in our newspapers the statement that Marconi hopes to communicate, by means of ether-waves, not just with some of the planets to which these would travel in a few minutes, but even with stars which are ten light-years or more distant. He proposes to use the universal truths of mathematics as an introduction to his sky-friends. With his wireless telegraph key he will send:—

.. (pause) .. (longer pause) ....

meaning "two and two are four," and in due time he expects the

answer to come back "yes." Just what signals will correspond to this word is not explained. It has been suggested that perhaps in some other spheres of existence the above simple mathematical law may not hold and the answer would be "no." Marconi believes that as we receive ether-waves [light] from the stars, they should receive our long ether wireless waves.

This idea of getting messages from the stars is not new. In 1900 Tesla installed powerful wireless apparatus on a mountain in the western states and he announced that he had noticed effects in his receiver for which he could not account and he therefore concluded that they must have been sent forth by the inhabitants of Mars.

Now to communicate by wireless telegraph or telephone over long distances is a marvellous accomplishment, but it is well to remember that the greatest distance is only a few thousand miles and the energy is guided by the surface of the earth. In the case of the planets and the stars, the distances are in millions of miles and the radiation would be out into space. The intensity would fall off inversely as the square of the distance and the power of the transmitting station would have to be multiplied many thousand times for the planets and thousands of millions of times for the stars.

It may seem cruel to clip the wings of the scientific imagination, but wireless communication with the other celestial bodies must be considered as a wild dream, without the slightest suspicion of being possible at the present time.

C. A. C.

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